Aim of the project: Epistemological development and evaluation of the proposal of an "extended synthesis" in evolutionary biology, with particular attention for the problems of criticism and growth of evolutionary theory, of integration among biological disciplines, and of implications for human and educational sciences.

State of the art: The Extended Evolutionary Synthesis (EES) is a recent perspective on contemporary evolutionary biology, supporting - in face of the proliferation of discoveries and fields - the necessity of an *extension* of the Modern Synthesis (MS) that was realized in 1930s and '40s around the development of population genetics (Huxley 1942; cf. Mayr & Provine 1980). Massimo Pigliucci, who has been for several years one of the main advocates of EES (e.g. 2005, 2007), wrote in 2007 that for many evolutionists «the MS provides *the* framework for current and future evolutionary biology, with no need to revisit the fundamentals», despite many novelties such as evolvability, phenotypic plasticity, epigenetics, complexity theory and more, which were unknown at the time of MS. On the other hand, there are more "continuist" perspectives that see evolutionary theory as *already* grown, although perhaps in ways different from the establishment of a new synthesis. Furthermore, some researchers are not yet persuaded that the the newly described phenomena have sufficient relevance and empirical support to justify a broad theoretical revision. There are also, although lying completely outside the scientific field of evolutionary biology, perspectives that see the same biological mechanisms as symptoms of the need for an entirely new theory to supplant the neo-Darwinian synthesis (e.g. Fodor & Piattelli Palmarini, 2010). In itself, the project of an EES (cf. Pigliucci & Müller 2010) appears still open and *in fieri* along various dimensions - empirical, theoretical, and epistemological.

This project is grounded on the consideration of EES as an interesting object of research for philosophy of biology, but also for philosophy of science in its most classical themes such as scientific change and the growth of theories (e.g. Kuhn 1962, Lakatos 1978, Lakatos & Musgrave 1974, Pievani 2010b); the project is radically oriented to interdisciplinarity, which is unavoidable in evolutionary biology (cf. e.g. Wake 2001, 2003, 2008), but moreover triggered by the contact between biological evolution and research fields belonging to human sciences (e.g.

evolutionary psychology, cultural evolution in economics, psychology of cognitive processes, communication sciences and social sciences); lastly, the project focuses on educational and didactical implications that are supposed to come form the reflection on EES and, more in general, on the evolution of evolutionary theory.

Expected results: Results are expected in distinct thematic areas: (A) Modern Synthesis and Extended Evolutionary Synthesis, (B) Criticism and growth of evolutionary theory and integration among biological disciplines, (C) Implications of the Extended Evolutionary Synthesis for human sciences, (D) Implications for teaching biology and interactions with educational sciences about science education.

Strengthening and widening of the existing network of international and national collaborations (see further on) is expected as well.

A) Modern Synthesis (MS) and Extended Evolutionary Synthesis (EES):

1. the project will *evaluate* the present degree of acceptance of EES (cf. Pigliucci & Müller 2010) in philosophical and scientific communities, Italian and international, highlighting strengths and limits of EES, both epistemological and empirical, that are identified by various subjects (cf. e.g. Godfrey-Smith 2007; Haig 2007; West-Eberhard 2007; Jablonka & Lamb 2007); it will *explicit* and systematically *criticize* the internal logic and epistemological assumptions of EES at its present stage; it will *develop* and specify the EES in relation to the major traditions in philosophy of science and philosophy of biology, in a continuing dialogue with evolutionary biologists of different specialities; it will *increase* the visibility and potential acceptance of EES by scientists in the international context;
2. the project will carry out a historical-philosophical *revision* of MS, realized in 1930s and '40s (Huxley 1942; cf. Mayr & Provine 1980), in relation to the established representations and rhetorical uses of MS that are found in philosophy of biology; it will *formulate* an epistemological notion of "theoretical synthesis" in evolutionary biology, and apply it to MS and EES.

B) Criticism and growth of evolutionary theory and integration among biological disciplines:

1. the project will *update* the perspective of "revision and extension" of the unique Darwinian evolutionary theory, seen as a solid but versatile theoretical architecture, which was expressed by Stephen Jay Gould (2002; cf. also Pievani 2010b); carry on an epistemological analysis of the modes of criticism and growth of the theory; reconsider categories such as explanation, law, pattern, prediction, corroboration, model and theory itself with the assumption (Pievani 2005) that philosophy of evolutionary biology has a great potential for innovation within philosophy of science, especially in Italy;
2. *compare* EES with the perspective of hierarchical theory of evolution proposed by Niles Eldredge (1985, 1995, 1999, 2000, 2008), in particular for what concerns the capacity of promoting integration among biological disciplines in the evolutionary theoretical framework;
3. *compare* different meanings of "theoretical synthesis", in particular the meanings that are implicit on the one hand in the idea of a "synthetic theory", and on the other end in synthetic approaches that are oriented by research questions on a case-by-case basis (Sidlauskas et al. 2009); analyze the possible *relevance* of theoretical synthesis in the growth of evolutionary theory and in the integration of biological disciplines.

(C) Implications of the Extended Evolutionary Synthesis for human sciences:

1. in light of EES, the project will renew a criticism to the uses of rigid and overpassed versions of evolutionary theory that are invoked to explain the natural history of human psychological qualities (e.g. *evolutionary psychology*);
2. analyze *cultural evolution* models in economics, in particular in comparison with the original models by Cavalli Sforza and Feldman (1973), inspired by population genetics; analyze the implications of EES's criticisms of population genetics for models of cultural evolution;
3. critically revise studies on *cognitive processes* involved in interpretation, organization, and classification of the organic world (cf. Serrelli 2010a): e.g. recognition of individuals, boundaries (e.g. Haber & Hamilton 2005; Haber,

Hamilton & Smith 2008; Haber 2010), categories, patterns (Eldredge 1999) and schemes of relations;

4. revise critically, in collaboration with communicational and social scientists, and also on the basis of EES and related themes, *influent metaphors and images* of evolution that are presently widespread in social communication and media.

(D) Implications for teaching biology and interactions with educational sciences about science education:

1. *development of implications* of reflections on EES for biological education and science communication, in particular for the planning of interdisciplinary curricula (e.g. Wake 2000, Eldredge 2008) and laboratory activities (cf. Pievani & Serrelli 2008; Serrelli 2011a);
2. *dialogue* with educational sciences on the themes of *scientific knowledge* and the "nature of science" (e.g. McComas 1998), for the identification of peculiar aspects and more general features of scientific education in relation to education in general.

Methods: The research will be carried on through a systematic and rigorous study of both scientific and philosophical literature; the preparation and submission of publications in which the points reached are argumented and exposed to be reviewed in the international reflection on evolutionary theory; discussions with scholars and international research institutions, both philosophical and scientific, by means of personal contacts (exchange visits, email communications, exchange of working papers) and the participation to debates in person (conferences, workshops) and online (forums and discussion groups in philosophy of biology, see e.g. PhilBioCafe http://philbiocafe.utah.edu).

This project is grounded on a view of philosophy of biology as a joint enterprise between philosophers and scientists on common interests that lie on the frontier of research (cf. Pievani 2005, 2010a). Interaction and reciprocal collaboration between philosophers and scientists is all the most necessary given the peculiarity of the project's theme, i.e. Extended Evolutionary Synthesis, whose main aims are integration among languages and discoveries in different biological specialities, and agreement upon a theoretical architecture that be able to guide research in the most effective way, by meanwhile honouring disciplinary peculiarities. Trans- and inter-disciplinary dialogue is, further, fundamental in the exploration of the relationships between the growing evolutionary theory and human sciences such as psychology and economy, as well as in the development of the contribution of educational sciences to scientific education.

The project will be based in the University of Milano Bicocca, where the promotion of several occasions of reflection and exchange are forecast, that should exploit the young University's openness, dynamicity, interdisciplinarity and strategic placement. Valid research resources in the University will be involved in the project, in particular: "Riccardo Massa" Department of Human Sciences for what concerns pedagogical expertise, laboratory activities, and the possibility to establish epistemological and methodological dialogue about scientific education; CISEPS - Inter-departmental Center for Interdisciplinary Studies in Economics, Psychology and Social Sciences - that have already experimented some seminars on cultural evolution, now constituted as a field of research in its own right; the Zooplantlab in the Department of Biotechnologies and Biosciences, directed by proff. Maurizio Casiraghi and Massimo Labra, that has a leading role in Italy in the integration among biological disciplines, to begin with the divisios between botany and zoology. More well-developed relationships - coming from past joint scientific activities - are up with University of Milano, "Luigi Gorini" Department of Biology, in particular with Marco Ferraguti, professor of Evolutionary Biology; University of Modena e Reggio Emilia, Department of Animal Biology, in particular with Mauro Mandrioli, professor of Genetics; University of Pavia, Department of Animal Biology, in particular with Daniele Formenti, professor of Anthropology; the Museum of Natural History of Milano, and Pikaia il portale dell'evoluzione (http://www.pikaia.eu), that are particularly meaningful for the themes of public communication of science (C4).

The research project will also avail itself of a wide and solid network of international relationships and collaborations, some of which are mentioned in the following section "temporal organization".

Temporal organization: The present project is divided in four phases, ideally corresponding to four years of work. The interdependence among phases, however, does not prevent the possibility of a remodulation of the project for the reaching a subset of the aims above listed in A-D.

First phase: The deepening of the proposal of an Extended Evolutionary Synthesis (A1) will take initial thrust from a workshop organized in December 2010 at the University of Milano Bicocca, concluding the PRIN 2007 research programme "The adaptive behaviour of biological systems and the scientific method". The workshop, entitled "Perspectives on the evolution of evolutionary theory: towards an extended synthesis?" will host Gerd Müller, chair of the Konrad Lorenz Institute for Evolution and Cognition Research in Vienna (http://www.kli.ac.at/), and editor with Massimo Pigliucci (City University of New York - Lehman College) of the book *Evolution: The Extended Synthesis* (MIT Press, 2010). In the workshop, Italian researchers from different perspectives will discuss strengths and critical aspects of the EES, and the proceedings will be developed and collected in a publication to be used for the evaluation of the welcoming of EES (A1), and for further discussion with Müller, Pigliucci, the contributors of *Evolution: The Extended Synthesis* and a more widened group of scientists and philosophers of science. The elaboration of a specific Italian contribution to the debate will be more worked out in occasions such as the V Congress of the Italian Society of Evolutionary Biology (http://www.sibe-iseb.it) that will be held in 2011.

Included in the research activities of CISEPS - Center for Interdisciplinary Studies in Economics, Psychology and Social Sciences - of the University of Milano Bicocca (http://dipeco.economia.unimib.it/ciseps/), again expanding form the workshop with Gerd Müller, the project will start to explore the implications of EES for human sciences (C), in particular for *cultural evolution* models (C2) that are more and more present in economical theory (Bowles 1998, Bisin & Verdier 2000, 2001). The line of research will be brought forth, e.g., by a dialogue with geneticist Luca Cavalli-Sforza (emeritus, Stanford University), who is interested in cultural evolution, and with P. Richerson and R. Boyd's research group at Stanford University, as well as by ad-hoc seminars, discussion groups and reading groups.

The meeting of ISHPSSB - International Society for the History, Philosophy, and Social Sciences of Biology (http://www.ishpssb.org) - that will be held in July 2011 in Salt Lake City, Utah, has reserved a session to the hierarchial theory of evolution (e.g. Eldredge 2000). The Society connects the major research in philosophy of biology. The session will be occasion for a development of the "theory" by the international Hierarchy Theory Research Group promoted by Niles Eldredge. The Group is working to the theoretical and empirical exploration of multiple "biological hierarchies", to the integration of biological subdisciplines (B2) with the assumption that they study entities at different spatiotemporal scales, and to the historical study and promorion of "hierarchical thinking" in evolutionary biology. Among the participants to the Group are Niles Eldredge and Ian Tattersall (paleontology, American Museum of Natural History, New York), Gregory P. Dietl (paleontology, Cornell University, New York), T. Ryan Gregory (genomic biology, University of Guelph, Ontario), William Miller III (paleoecology, Humboldt State University, CA), Daniel R. Brooks (biodiversity and systematics, University of Toronto), Telmo Pievani and Emanuele Serrelli (philosophy of biology, university of Milano Bicocca). To the aim of the present project, the Hierarchy Theory Research Group's workings will be confronted with EES (B2), especially in regard to the capacity of promoting integration among biological disciplines (Eldredge 2008).

In 2011 in Athens will be held the Third Conference of the young EPSA - European Philosophy of Science Association (http://www.epsa.ac.at/). The proposal of a paper or a session about the philosophical themes emerging from the revision of evolutionary theory (B) will allow this project to advance in the philosophical discussion of the "revision and extension" of scientific theories (B1) and in the improvement of visibility of EES-related problems (A1). It will be also the opportunity to give a potentially interesting contribution to the building of European voices in the debate in philosophy of biology, until today almost completely held by the American Philosophy of Science Association (http://www.philsci.org). The contacts with prof. Vicente Claramonte Sanz of the University of Valencia, and with the network Asociación Iberoamericana de Filosofia de la Biología, will be equally important in this phase.

Second phase: 2012 will be characterized by the celebration of the ten-years anniversary of Stephen Jay Gould's death. Gould's thought, much discussed throughout his life (cf. e.g., Sterelny 2001, Ferraguti 2004), did not cease to constitute a hallmark reference for any debate on evolutionary theory. Accordingly, 2012 will undoubtedly be the occasion to sum up Gould's heritage, and to make the point anout the validity of the positions he expressed in his works. The monumental book *The Structure of Evolutionary Theory* (Belknap Harvard), published in 2002 just before he died, is among the great contributions by Harvard's famous paleontologist: a long argument around the idea that evolutionary theory has an "architectural" identity dating back to Charles Darwin's foundation, but importantly modified in its structure. This research project will exploit the occasions offered in 2012 to specify the "architectural" idea of the updating of evolutionary theory, comparing it with the more recent proposal of EES (B1) and pointing out continuities and differences.

In parallel, the historical-philosophical work on the Modern Synthesis (A2) will be carried out. Realized in 1930s and '40s (Huxley 1942; cf. Mayr & Provine 1980), the MS is unanimously recognized as a fundamental step in the building of evolutionary theory as it is today. Fundamental feature of MS was the conciliation between the theory of natural selection and Mendelian genetics, a conciliation carried out most of all by means of the building of mathematical models of population genetics. Both theories were corroborated by MS. Another fundamental aspect was the creation of a common language connecting different disciplines and approaches, from e.g. genetics to zoology to paleontology. The EES points out MS's explanatory limits but, at the same time, it aspires to replicate it as a unifying epistemological phenomenon. Established representations and rhetorical uses of MS that are found in philosophy of biology - including those that are brought in support of EES - will be analyzed, put into discussion, and confronted with the results of a renewed historical-epistemological analysis, discussed in turn with expert scholars such as prof Anya Plutynski, Department of Philosophy, University of Utah (e.g. Plutynski 2005).

Third phase: Capitalizing the studies on MS (A2), the project will follow up the analysis, evaluation and redefinition of EES (A1). Then it will proceed in a more precise way to the formalization of the notion of a "theoretical synthesis" (B3), comparing the different meanings of it intended, on the one hand, with the the idea of a "synthetic theory" and, on the other hand, with the synthetic approach promoted and theorized by NESCENT - National Evolutionary Synthesis Center (http://www.nescent.org/) - located in Durham, North Carolina (cf. Sidlauskas et al. 2009). The center - operated by Duke University, The University of North Carolina at Chapel Hill and North Carolina State University, and sponsored by the National Science Foundation - is devoted to interdisciplinary research on evolution. Evolutionary "synthesis" is - in the NESCENT approach - a realization guided from time to time by research questions, and oriented to them, and synthesis assumes several forms such as integration of new data and models, development of novel analytic approaches and tools, and the combination of methods and perspectives from different disciplines. In contact with NESCENT, the research project will confront its achievements about EES and MS (A2) with a very different but scientifically authoritative approach, in order to further articulate and specify the concept of "theoretical synthesis" (B3).

Third phase will be also devoted to a more extensive exploration of the implications of EES for human sciences (C). In contact with scholars such as Stephen M. Downes (University of Utah, e.g. 2008, 2009a, b), Kim Sterelny (e.g. 2003), Paul E. Griffiths (Sydney Centre for the Foundations of Science, e.g. 2008) who have internationally confronted with such themes, the project will reaffirm the criticism to the use of rigid and overpassed versions of evolutionary theory for the explanation of human psychological qualities (C1), renewing and expanding such a criticism from EES. Collaborating with CISEPS (University of Milano Bicocca) studies will be done on cultural evolution in economics (C2), with the twofold, desirable result of an advancement of evolution-inspired modeling and a clearer and deeper epistemological understanding (e.g. Godfrey-Smith 2009) of bridges between biological and cultural evolution (beginning with clarifications on what is to be intended as "culture"). The interdisciplinary link between biology and economy will also offer a renewed occasion to reflect upon a rather classical theme in philosophy of science (B1), i.e. the use of models in science (e.g. Serrelli 2010b, Downes 1992, Godfrey-Smith 2006). Relating scientific knowledge of evolution and

EES with *folkbiology* (Serrelli 2010a) - i.e. the study of cognitive processes by which people of different cultures make sense of the organic world - this project will get to deal with the intertwining between scientific knowledge and cognition (cf. e.g. Haber 2010 on the recognition of boundaries and individuals) (C3), hopefully contributing to researches in anthropology and cognitive psychology, and in any case earning some points in view of the argument of scientific education (D1) that will be confronted with in the fourth phase. Finally, communication and social sciences will be involved in the research - always in relation to EES - on influent metaphors and images of evolution that are conveyed by social communication and media (D4), as well as on the problems of their change, and on the different uses of "new media" that the epistemological changes in evolutionary biology can stimulate.

Fourth phase: The last phase in the project will be devoted to the dissemination of results. Reflections and interactions that will have been produced throughout the various phases and still wait to be made public, will be systematized and published mostly in the form of papers on specialized peer-reviewed journals such as *Biology & Philosophy*, *Philosophy of Science*, *European Journal for Philosophy of Science* and similar. Joint publications with scholars that will have been involved in the project will be privileged, in order to consolidate the built relationships. Particular attention will be given to the project's general aim: the epistemological development and evaluation of the proposal of an "extended synthesis" in evolutionary biology, the increase of its visibility and of its possible acceptance by scientists in the international context (A1).

Under the title dissemination, there is also a further important theme of research. It will be carefully prepared during the first three phases of work, but will receive specific and systematic attention in the fourth: the theme of the implications of EES (and related reflections) on teaching biology (D1), in particular for the planning of interdisciplinary curricula (Wake 2000, Eldredge 2008) and educational laboratory activities (Pievani & Serrelli 2008). As usual, this theme of research will benefit from international exchanges with people such as Eugenie C. Scott of NCSE (National Center for Scientific Education, http://ncse.com/) who will be guest of University of Milano Bicoccain Fall 2010, or Adam C. Goldstein (Iona

College, New York) and the editors of the peer-review journal *Evolution: Education & Outreach* (cf. e.g. Serrelli 2011b). However, fundamental in this phase will be the collaboration within the "Riccardo Massa" Department of Human Sciences and "Facoltà di Scienze della Formazione", where - in view of the fourth phase - as many colleagues as possible will have been involved in the project and informed about it. Aside from consultation and collaboration upon effective laboratory activities and curricula, it will be interesting - at the end of the project - to conduct a deeper reflection on the "nature of science" (e.g. McComas 1998, Bell et al. 2001), on the modes by which science discovers, grows, and changes, on the extent to which all this can reverberate in a real scientific education, and finally on the relationships that go between scientific education and education and teaching in general (D2).

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